

EXHIBIT 1

Public Redacted Version

**UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION**

**IN RE GOOGLE PLAY STORE ANTITRUST
LITIGATION**

Case No. 3:21-md-02981-JD

THIS DOCUMENT RELATES TO:

In re Google Play Consumer Antitrust Litigation,
Case No. 3:20-cv-05761-JD

State of Utah et al. v. Google LLC et al.,
Case No. 3:21-cv-05227-JD

DECLARATION OF DR. GREGORY K. LEONARD

August 14, 2023

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I. QUALIFICATIONS

1. My name is Gregory K. Leonard. My qualifications are summarized in my rebuttal report submitted on November 18, 2022. My updated curriculum vitae is attached to this declaration as Exhibit A.

II. ASSIGNMENT

2. In this declaration, I provide answers to the questions posed by the Court in its Order Re Dr. Singer's Proposed Expert Testimony, dated August 6, 2023.

3. The materials I have considered in preparing this declaration include materials previously identified in Appendix B of my November 18, 2022 Expert Report ("Leonard Report"), materials previously identified in Appendix B of my June 14, 2023 Supplemental Report ("Leonard Supplemental Report"), and materials cited in this declaration.

III. ANSWERS TO THE COURT'S QUESTIONS

A. What economic literature states that a regression analysis is a reliable way of (i) testing for the IIA assumption in the logit model, or (ii) confirming that a logit model can be used to reliably measure the relevant demand curve here?

4. By "a regression analysis," I assume the Court means the specific regression analysis that Dr. Singer employed in his expert report.¹

¹ This point of clarification is important because some of the true tests of the IIA assumption—tests that Dr. Singer never ran—can be performed using regression analysis; but those regression analyses are entirely different than the ones Dr. Singer employed.

1. Summary Answer

5. I am not aware of any economic literature that supports Dr. Singer's regression analysis as a reliable way to test the IIA assumption or to confirm that the logit model is appropriate for a given real world situation. What the literature has done, however, is to develop several generally accepted and widely used tests of the IIA assumption. Rather than using one of those tests, Dr. Singer employed the unsupported "test" of his own making that is, as a matter of logic, incapable of testing the IIA assumption. Similarly, his claimed test of the reliability of the logit model is unsupported by the literature and invalid.

2. Detailed Answer

6. The defining characteristic of the logit model is the IIA assumption, which forces a particular substitution pattern on the data, regardless of how consumers actually substitute among products in the marketplace being studied. The logit model that Dr. Singer used in this case assumes that all apps in a given app category are substitutes and that substitution from one app to every other app in the category is strictly in proportion to their category shares. As an example, suppose there are four apps in a category, A, B, C, and D, with category shares of 10%, 20%, 30%, and 40%, respectively (totaling to 100%). Suppose that App A increases its price and, as a result, some of its customers substitute away to other apps in the category. The IIA assumption says that—regardless of how the prices and features of apps B, C, and D compare to those of app A—app B would capture $20\% / (100\% - 10\%) = 22\%$ of the customers substituting from app A, while app C would capture $30\% / (100\% - 10\%) = 33\%$ of those customers and app D would capture

$40\%/(100\%-10\%) = 44\%$.² Under the IIA assumption, substitution patterns are assumed to be driven entirely by shares.

7. As a matter of basic logic, Dr. Singer's regression analysis is incapable of testing the IIA assumption. Dr. Singer's regression relates an app's own share to its own price (and not the prices of other apps). Thus, at best, it measures the extent to which an app loses its own share when its own price increases.³ Dr. Singer's regression analysis is not able to say, however, where the app's share losses go, i.e., to which other apps consumers substitute and the extent of that substitution. Because it does not measure the extent of substitution among apps at all, Dr. Singer's regression is incapable of testing whether substitution is proportional to shares, which is to say that it is incapable of testing the IIA assumption.⁴

8. Because Dr. Singer's regression analysis is incapable of testing the IIA assumption, it is not surprising that there is no support to be found in the economics literature for the proposition that Dr. Singer's regression analysis provides a valid test of the IIA assumption.

9. There are, however, several types of tests of the IIA assumption to be found in the literature, and these tests are well-known, generally accepted, and widely used. The first type (published in

² The reason apps B, C, and D have their shares divided by $100\%-10\% = 90\%$ when calculating the substitution percentages is that switchers away from app A by definition would go to the other apps in the category, which together constitute 100% minus app A's 10% share, or 90%.

³ Merits Report of Dr. Hal Singer, October 3, 2022 ("Singer Report"), ¶¶ 347-348, 353, and Table 12. The dependent variable in Dr. Singer's regression analysis is the logarithm of the app's category share divided by the share of the "outside good," which represents any product outside the category. I note that Dr. Singer assumed that the share of the outside good is zero in deriving his pass-through formula from the logit model. Thus, he made different assumptions for the logit model of his regression analysis and for the logit model underlying his pass-through formula.

⁴ Dr. Singer's regression analysis is also incapable of measuring the extent of pass-through of service fees because it does not include the service fee as a variable. To measure pass-through, a different regression analysis would be needed, one that explicitly relates an app's price to the service fee. That is precisely what I did in my Expert Report, where I found that the pass-through rate was not statistically significantly different from zero. Leonard Report, Section V.B.2.b.

1984) is based on the idea that, if the IIA assumption is correct, approximately the same results should be obtained if the regression is run on any subset of choices (here, apps) rather than the entire category.⁵ Conversely, if the IIA assumption is incorrect, different results will tend to be obtained when running the regression on different subsets of choices. To see why, consider the case of four apps where apps A and B are nearly perfect substitutes and apps C and D are more distant substitutes, both for each other and for apps A and B. The IIA assumption would be incorrect in this case because substitution would not be proportional: if app A were to raise its price, its share losses would shift almost entirely to app B, with very little share shifting to apps C and D. If the logit model were fit using data for all four apps, the regression would be “confused” by the deviation of actual substitution patterns from IIA and mistakenly attribute the large shifts in share between apps A and B to price sensitivity when in fact the large share shifts were due to apps A and B being much closer substitutes than the IIA assumption allows. If the logit model was instead fit to the subset consisting only of apps C and D, the regression would find less price sensitivity because the cause of the “confusion” (i.e., apps A and B being nearly perfect substitutes) will have been omitted from the regression. A difference in regression results between using the full set of four apps and the subset of apps C and D would be an indication of the failure of the IIA assumption and the need for an alternative model of demand.

10. The second type of test of IIA that has been developed in the literature is to estimate a model (such as random coefficients logit discussed below) that allows more flexible substitution patterns than logit and then test the restrictions on the more flexible model that would be required

⁵ J. Hausman and D. McFadden, “Specification Tests for the Multinomial Logit Model,” *Econometrica*, 1984 (“Hausman and McFadden (1984)”), pp. 1219-1240.

for it to collapse to the simple logit model.⁶ For example, after estimating a random coefficients logit model, the substitution patterns among products implied by the model could be calculated. These implied substitution patterns will reflect the underlying reality of the marketplace because of the flexibility of the random coefficients model. If the IIA assumption is correct for the market in question, one should see that the implied substitution patterns that emerge from the random coefficients logit model are proportional to shares. If, on the other hand these substitution patterns are not proportional to shares, one can conclude that the IIA assumption fails and the more flexible model is needed.

11. Despite the availability of these tests and their widespread use in the literature⁷, Dr. Singer performed none of them. At the “hot tub,” I heard Dr. Singer claim that he did not have the data required to run these generally accepted tests of the IIA assumption. First, lack of data is not a reasonable excuse for an economist to adopt, without any testing, an assumption like IIA that has been heavily criticized in the literature and for which substantial doubt exists as to its validity for the situation at hand (see more on this below). If IIA fails to hold for Android apps, Dr. Singer’s logit model is an invalid basis for his pass-through formula. Yet, because he did not perform the generally accepted tests of IIA, he cannot reasonably claim to know whether IIA holds or not. Second, his claim as to lack of data is simply false. The tests described above could be performed using the data Dr. Singer has or data he could have gathered. For example, the first type of test

⁶ See K. Train, *Discrete Choice Methods with Simulation*, Cambridge University Press, 2009 (“Train (2009)”), p. 50: “For more flexible specifications, such as GEV and mixed logit, the simple logit model with IIA is a special case that arises under certain constraints on the parameters of the more flexible model. In these cases, IIA can be tested by testing these constraints. For example, a mixed logit model becomes a simple logit if the mixing distribution has zero variance. IIA can be tested by estimating a mixed logit and testing whether the variance of the mixing distribution is in fact zero.”

⁷ For example, a Google Scholar search on August 13, 2023 finds 3,709 citations to the Hausman and McFadden (1984) paper, with 758 citations since 2019.

can be run on subsets of apps within a category, which requires no additional data beyond what Dr. Singer already has. In fact, Dr. Singer ran his logit model separately for different subcategories of games, which allows for this first type of test of the IIA assumption.⁸ He found substantially different price coefficients for the different game subcategories (e.g., the price coefficient for card games is almost four times the price coefficient for sports games) and, given their small standard errors and statistical independence, one can conclude confidently that the IIA assumption would be rejected by a formal statistical test. The second type of test of the IIA assumption can also be run using shares for subsets of apps, data that Dr. Singer already has, or by gathering publicly available information on app characteristics.

12. Dr. Singer may claim that, even if his regression analysis has not tested the IIA assumption, it nevertheless “confirm[s] that a logit model can be used to reliably measure the relevant demand curve,” as the Court put it in its question. In particular, Dr. Singer has previously pointed to the “fit” of his regression model (also known as the R-squared) to support his use of the logit model.⁹

13. However, I am not aware of any economics literature that states that Dr. Singer’s regression analysis is a valid way to confirm whether a particular type of demand curve (here, logit) can reliably be used for a given situation.

⁸ Singer Report, Appendix 6. Given that Dr. Singer reported only rounded p-values, calculation of the exact standard errors for the coefficients, and thus a formal test statistic, from his reported results in Appendix 6 is not possible. However, it can be inferred that the standard errors are sufficiently small that the formal test would reject the IIA assumption.

⁹ Singer Report, ¶¶ 354-355. Dr. Singer also pointed to the fact that he obtained the “right” signs and statistical significance on the price coefficients in his regression model as support for the logit model. However, these findings are a low bar—all demand models predict lower share (i.e., lower quantity) when price increases and vice versa. Thus, in and of itself, finding the “right” signs and statistical significance in Dr. Singer’s regressions is not convincing evidence in favor of the logit model over any other demand model.

14. There are several reasons why Dr. Singer's regression analysis is not a valid approach for assessing the reliability of a particular demand model in a given situation. First, as a logical matter, a model's "fit" is meaningful only when compared to that of an alternative demand model. For example, it might sound impressive that one demand model has an R-squared of 95%. But, if another demand model has an even larger R-squared of 99%, the first model's fit standing alone is misleading. Thus, to support the use of one demand model, one should compare its fit to the fit of alternative demand models. Yet, in his opening report, Dr. Singer presented no comparison of the fit of logit model to that of any other demand system. He just presents the R-squared of the logit model in isolation.

15. In his reply report, Dr. Singer belatedly compared the logit model to the linear demand model.¹⁰ However, he was unable to compare the fits of the two models because they use different dependent variables.¹¹ So, he instead made a comparison of the signs and statistical significance of the price coefficients from the respective models. However, he made an error in calculating statistical significance of the price coefficients for the linear model, which substantially undercuts his claim that the logit model was superior along this dimension.¹² But, even so, a statistical significance comparison is not a valid test of one model against another. For example, the logit model could have severe bias that produces statistical significance but an unreliable result.

¹⁰ Merits Reply Report of Dr. Hal Singer, December 23, 2022 ("Singer Reply Report"), fn. 19 and 96, and Appendix 3.

¹¹ There are non-nested hypothesis tests that Dr. Singer could have used to compare the two models, but he declined to do so. See, for example, J. MacKinnon, "Model Specification Tests against Non-Nested Alternatives," *Econometric Reviews*, 1983, pp. 85–110; M. McAleer, "The Significance of Testing Empirical Non-Nested Models," *Journal of Econometrics*, 1995, pp. 149–171.

¹² Dr. Singer failed to account for heteroskedasticity in the error terms using an approach that has been widely accepted since 1980. See H. White, "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity," *Econometrica*, 1980, pp. 817–838.

Moreover, Dr. Singer's choice of the linear model as the one and only demand model against which to "compare" the logit model's coefficients' statistical significance is curious given that, as discussed below, the most commonly used model in industrial organization is the random coefficient logit model. He seems to have studiously avoided any comparison of his logit model to the "workhorse" model of industrial organization economics.

16. A final point about "fit." Dr. Singer's claim that the logit model has a 95% R-squared is itself misleading. As I noted at the outset, Dr. Singer's regression relates an app's share to its price as well as a large set of indicator variables that attempt to control for, among other things, differences among apps in their features, quality, popularity, etc. that affect share apart from price. These indicator variables—which would be included in many demand models and thus are not a feature specific to the logit model—account for the large majority of the 95% R-squared that Dr. Singer reports. For example, if the indicator variables are omitted from Dr. Singer's regression model, leaving only the price variable, the R-squared of Dr. Singer's logit regression drops from 95% to 18%. Conversely, if the price variable is dropped, leaving only the indicator variables, the R-squared barely decreases, remaining at 95%. This set of results demonstrates that the "fit" that Dr. Singer claims supports his logit model in fact is driven largely by the indicator variables that would be found in virtually any empirically estimated demand model. Dr. Singer misleadingly attributes his claimed "fit" to the logit model when he should have recognized that the "fit" was in fact due to the indicator variables that have nothing to do with whether logit is an accurate approximation to the structure of demand. Given that most of the "fit" he touts is not properly attributed to the logit model itself, Dr. Singer's use of "fit" as support for his logit model as opposed to other demand models is further undercut.

B. To what extent can IIA be “not strictly satisfied” before the use of logit model becomes unreliable? How can the Court know that this limit has not been crossed here? How close is the “approximation” that Dr. Singer posits, and how can the Court have confidence that his logit model has produced a sufficiently reliable approximation of pass-through here even if the apps in each category are not proportional substitutes for one another?

1. Summary Answer

17. Economists are wary of making the IIA assumption given its strong a priori restrictions on substitution patterns and, in the case of Android apps, the IIA assumption is clearly false given that the categories Dr. Singer used contain apps that are not substitutes at all for each other. In addition, the true test of a model is whether it predicts real world outcomes accurately. Dr. Singer’s pass-through formula, based on the logit model and its IIA assumption, woefully fails to predict the real-world pass-through behavior of app developers as the empirical pass-through analyses in my reports demonstrate. These failures of Dr. Singer’s model to accurately predict real world outcomes tells the Court everything it needs to know about whether Dr. Singer’s model is a sufficiently accurate “approximation.” It is not.

2. Detailed Answer

18. Economists are wary of using demand models that use the IIA assumption. The economics literature has recognized that the IIA assumption represents the a priori imposition of “unrealistic” substitution patterns.¹³ Accordingly, one of the most important achievements in the demand

¹³ See S. Berry and P. Haile, “Foundations of Demand Estimation” in *Handbook of Industrial Organization*, North-Holland, 2021, pp. 1-62: “Some of the simplest demand specifications (e.g., the CES, multinomial logit, multinomial probit) impose strong a priori restrictions on demand elasticities and, therefore, on markups, pass-through, and other key quantities of interest that are at odds with common sense and standard economic models;” “To be clear, the problem [with IIA] is not just a lack of ‘realism,’ but the a priori restriction on key features like own and cross-price elasticities that motivate estimation of demand... This is a bug, not a feature. These restrictions do not come from economics but from assumptions chosen for simplicity or analytical convenience. Models must, of course, abstract from reality, and finite samples require appropriate parsimony. But good

estimation literature over the last 30 years has been the development of demand models that relax the IIA assumption to allow for more flexible and realistic substitution patterns that can fit actual market outcomes. The most prominent of these models is called “random coefficients logit.” Unlike logit, the random coefficients logit model does not make the IIA assumption and, indeed, was developed precisely to avoid the IIA assumption. These more flexible models have become the “workhorse” models of empirical industrial organization¹⁴, to the point that today logit and other IIA-based demand models are rarely used in empirical industrial organization studies.

19. Turning to the specific case of Android apps, given the category definitions that Dr. Singer used, the IIA assumptions of the logit model that all apps are substitutes and substitution is proportional to shares are clearly false. Some of the apps within a category are not substitutes for

modeling and approximation methods should aim to avoid strong a priori restrictions on the very quantities of interest unless those restrictions can be defended as natural economic assumptions.” Professor Berry has been making this same point for 30 years. See S. Berry, “Estimating Discrete-Choice Models of Product Differentiation,” *RAND Journal of Economics*, 1994, pp. 242-262: “[t]he logit model produces unreasonable substitution patterns.”

¹⁴ See B. Salanié and F. Wolak, “Fast, ‘Robust,’ and Approximately Correct: Estimating Mixed Demand Systems,” *NBER Working Paper 25726*, 2019: “[the random coefficients logit model] is the workhorse of empirical IO;” C. Conlan and J. Gortmaker, “Best Practices for Differentiated Products Demand Estimation with PyBLP,” *RAND Journal of Economics*, 2020, pp. 1108-1161: “Empirical models of supply and demand for differentiated products are one of the most important achievements of the New Empirical Industrial Organization (NEIO) literature of the last 30 years. The workhorse model is the [random coefficients model], which provides an estimator that allows for flexible substitution patterns across products...The [random coefficients model] ha[s] been used in a wide variety of applications: understanding the value of new goods..., evaluating the price effects of mergers,...and studying two-sided markets...the [random coefficients logit] approach has been extremely influential in the practice of prospective merger evaluation, particularly in recent years”; A. Gandhi and J. Houde, “Measuring Substitution Patterns in Differentiated-Products Industries,” *NBER Working Paper 26375*, 2020, p. 1: “The extent to which competing products are substitutable is central to empirical Industrial Organization (IO) because it is informative about magnitude of market power and consumer welfare in differentiated-product industries. The [random coefficients logit model] is the leading approach for estimating demand in this context...This class of models can approximate very rich substitution patterns by relaxing the Independence of Irrelevant Alternatives (IIA) assumption underlying logit/CES type demand structure”; L. Pál and Z. Sándor, “Comparing Procedures for Estimating Random Coefficient Logit Demand Models with a Special Focus on Obtaining Global Optima,” *International Journal of Industrial Organization*, 2023: “The [random coefficient logit model has] become a workhorse in industrial organization for in-depth analysis of various competition policy issues. These include, but are not limited to, analyzing the welfare effects of mergers, tax changes or the introduction of new products.”

each other at all, let alone in a manner proportional to their respective shares. As illustrated by the example below, “Rosetta Stone,” “Duolingo,” and “PictureThis - Plant Identifier” are three apps in the Education category, with category shares of [REDACTED] respectively as of May 2022. Rosetta Stone and Duolingo are language learning apps and therefore potentially substitutes for each other. PictureThis – Plant Identifier, on the other hand, helps a user identify plants. With entirely different functionality than the language learning apps, there can be no serious argument that PictureThis – Plant Identifier is any kind of substitute at all for Rosetta Stone. Yet, the logit model, with its IIA assumption, assumes that if Rosetta Stone raised its price and some customers substituted away, PictureThis – Plant Identifier would capture a larger percentage of these switching customers than Duolingo ([REDACTED] versus [REDACTED]) simply because PictureThis – Plant Identifier has a larger category share than Duolingo. This makes no economic sense at all. Rather, PictureThis – Plant Identifier would be expected to capture few, if any, of the customers switching away from Rosetta Stone (versus [REDACTED] as predicted by the logit model). Duolingo, on the other hand, given the similarity of its offering to Rosetta Stone, likely would capture Rosetta Stone switchers out of proportion to its category share.

App Name	Category Share	Logit Model's Assumption Regarding Percentages of Switching From "Rosetta Stone" to "Duolingo" and "PictureThis - Plant Identifier"
Rosetta Stone	[REDACTED]	
Duolingo	[REDACTED]	[REDACTED]
PictureThis - Plant Identifier	[REDACTED]	[REDACTED]

Notes: Given that Dr. Singer calculated category share at the level of app category-purchase type-month, the category share is calculated as the unit share of Rosetta Stone (air.com.rosettastone.mobile.CoursePlayer), Duolingo (com.duolingo), and PictureThis - Plant Identifier (cn.danatech.xingseus) in May 2022 for the purchase type of subscriptions in the app category of Education.

Data: Google Play transactions data.

20. Milton Friedman famously stated:

[...] the relevant question to ask about the “assumptions” of a theory is not whether they are descriptively “realistic,” for they never are, but whether they are sufficiently good approximations for the purpose in hand. And this question can be answered only by seeing whether the theory works, which means whether it yields sufficiently accurate predictions.¹⁵

21. Dr. Singer never compared the pass-through predictions of his logit model against real world outcomes. I, on the other hand, provided such a comparison in both my Report¹⁶ and my Supplemental Report.¹⁷ In those reports, I demonstrated that Dr. Singer’s logit-based pass-through formula woefully fails to predict real-world pass-through behavior. This failure means that Dr. Singer’s logit model does not provide a sufficiently reliable approximation of pass-through by apps in the Play store.

22. To briefly recap, Google has implemented two reductions in service fees that allow one to analyze real world developer pass-through behavior. First, in July 2021, Google reduced the service fee to 15% for developers with annual Play revenues of less than \$1 million. Second, in January 2022, Google reduced the service fee for all subscription apps to 15%.¹⁸ These two events represented substantial decreases in service fees for many SKUs. If Dr. Singer’s logit model provided a reasonable approximation to real world pass-through behavior, its testable implication is that we should have observed that every developer who received a service fee reduction substantially lowered its SKU prices in response. My analysis shows that did not happen. Most

¹⁵ M. Friedman, *Essays in Positive Economics*, University of Chicago Press, 1953, p. 15.

¹⁶ Leonard Report, Section V.B.2.

¹⁷ Leonard Supplemental Report, Section IV.

¹⁸ Google announced each change approximately four months in advance, giving developers ample time to make adjustments to their app prices.

developers did not lower their SKU prices despite paying lower service fees. Thus, the predictions of Dr. Singer's logit model pass-through formula do not comport with real-world outcomes. Accordingly, Dr. Singer's logit model is not a reliable approximation of real-world behavior.

23. Dr. Singer has attempted to explain the failure of his pass-through formula to predict real-world pass-through in several ways, all of which are deficient. I addressed the deficiencies of these purported explanations in my Report.¹⁹ At the "hot tub," I heard Dr. Singer point to developers for whom the July 2021 service fee reduction was "temporary" and not "economically meaningful" because they eventually exceeded the \$1 million revenue threshold and reverted to 30%. He claimed that such developers may not have responded to the service fee reductions due to their temporary nature and small magnitude. However, Dr. Singer ignores the fact that his logit model and pass-through formula imply an immediate response by developers to even a small or temporary service fee reduction.²⁰ Moreover, Dr. Singer elsewhere claimed that the incentive for a developer to pass a service fee reduction through would exist even in the "short run."²¹

24. Importantly, Dr. Singer also ignores the fact that there are a large number of SKUs associated with developers that remained below the \$1 million threshold for an extended period of time. In total, there are tens of thousands of SKUs for which the service fee was reduced to 15% in July 2021 and remained at 15% through May 2022 (the last period for which we have data); among these, the large majority also had a service fee of 30% before July 2021, which was then

¹⁹ Leonard Report ¶¶ 84-85.

²⁰ Dr. Singer did not build any distinction between short run and long run responses, any distinction between small and large service fee reductions, or any other kind of friction into his pass-through formula or his logit model regressions.

²¹ Singer Class Reply Report ¶ 31: "the basic economic logic of pass-through applies both to short-run and long-run profit maximization...In the short run, positive marginal costs are sufficient to generate pass-through given a change in the take rate."

reduced to 15% from July 2021 to May 2022.²² Thus, there were many SKUs for which the decrease in service fee in July 2021 was large and long-lived. Dr. Singer has no explanation for why his pass-through formula failed to predict the pass-through behavior of the developers of these tens of thousands of SKUs. Similarly, Dr. Singer entirely ignores the January 2022 reduction in service fee to 15% that applied to all subscriptions (there was no revenue threshold), of which there were also tens of thousands in January 2022. Again, he has no explanation for why his pass-through formula failed to predict the pass-through behavior of the developers of these tens of thousands of subscription SKUs.²³

25. A further indication of the unreliability of Dr. Singer's pass-through formula is that it produced a but-for world that makes no economic sense. In his Supplemental Reply Report, Dr. Singer for the first time in this case calculated but-for service fees and but-for prices for individual plaintiff transactions. As his own backup materials show, there are instances where Dr. Singer's but-for price for a SKU is higher when its but-for service fee is lower.²⁴ For example, for one SKU, Dr. Singer has the but-for service fee decrease from 14.15% to 7.07% between February 28, 2021 and March 28, 2021 and the but-for price increase from \$9.01 to \$9.86 over the same time period. This makes no economic sense given Dr. Singer's claims in this case that a lower service fee should have led to a lower app price. The reason that Dr. Singer's model produces this anomalous result is the disconnect between (1) the model's assumptions that pass-through would

²² These include a mixture of paid apps, IAP SKUs, and subscription SKUs.

²³ Dr. Singer may claim that the five months of data we have after the January 2022 service fee reduction was not a sufficiently long period to observe pass-through for subscription SKUs. However, as noted above, Google announced the change four months in advance, giving a developer nine months to reduce its subscription SKU prices. As also noted above, Dr. Singer claims that the incentives to pass through exist in the "short run."

²⁴ Supplemental Merits Reply Report of Dr. Hal Singer, June 30, 2023 ("Singer Supplemental Reply Report"), backup workbook.

be large and apply to all SKUs and (2) the real-world fact that pass-through was non-existent or minimal for many SKUs.²⁵

26. At the “hot tub,” Dr. Singer tried to claim that economist Dr. Ken Train has written that the IIA assumption is not really a problem because a logit model can always be set up so that it is appropriate. I have known Dr. Train for many years, was a colleague of his at NERA Economic Consulting, and worked with him on projects involving estimation of discrete choice models. Dr. Singer has grotesquely misinterpreted Dr. Train’s writings. Dr. Train’s professional accomplishments as an economist have been centered around developing models that relax the IIA assumption. Why would this be necessary if he thinks that a logit model can always be set up properly to avoid the consequences of the IIA assumption?

27. In fact, the thrust of Dr. Train’s book is to encourage the use of more advanced models that relax the IIA assumption. Dr. Train describes the problems with IIA²⁶ and the tests that can be used to determine whether the IIA assumption is violated in a given application, noting that “whether IIA holds in a particular setting is an empirical question, amenable to statistical investigation.”²⁷ He then devotes the large majority of the book to more flexible models and the econometric estimation of those models.

²⁵ Dr. Singer has attempted to explain away the anomaly by claiming that not everything was held constant because (if I understand his nonsensical explanation correctly) the actual world service fee decreased. However, a properly constructed but-for world should be internally consistent and independent of what happened in the actual world. Indeed, the but-for world is supposed to be a counterfactual. Referencing events in the actual world to explain anomalies in the constructed but-for world makes no sense. Rather, the anomalies show that Dr. Singer’s construction of the but-for world was faulty.

²⁶ Train (2009), p. 48 (“Proportionate substitution can be realistic for some situations, in which case the logit model is appropriate. In many settings, however, other patterns of substitution can be expected, and imposing proportionate substitution through the logit model can lead to unrealistic forecasts.”).

²⁷ Train (2009), pp. 49-50.

28. In the passage of the book to which Dr. Singer is apparently referring,²⁸ Dr. Train explains that, as a theoretical matter, if it was possible to gather information on enough characteristics of the apps and characteristics of individual consumers and include these characteristics as variables in a logit model such that the only aspect of a consumer's preferences that was left unexplained was quirky "white noise," then IIA would be satisfied. However, Dr. Train does not assert that, in practice, this is typically possible. Rather, he refers to it as the "ideal." And, again, the rest of his book is devoted to explaining the use of models that should be used in the typical case where the "ideal" is not possible to achieve.

29. Dr. Singer's model comes nowhere close to achieving the "ideal." He has not gathered information on a plethora of app and individual characteristics that he then includes in his logit model. Rather, he includes only the app price and a set of SKU-time-state indicator variables. This leaves plenty of room for substantial correlation among the remaining unobserved portions of a consumer's utilities for apps. For example, consumers who like a given single-shooter game likely also like other single-shooter games (and those consumers who do not like one such game likely will not like others as well). That is, such consumers will exhibit positive correlation among the unobserved parts of their utilities for single-shooter games. The unobserved portions of their utilities are not just "white noise." The price and indicator variables included in Dr. Singer's model would not capture this correlation in consumers' preferences over single-shooter games and therefore the "ideal" would not be met and the logit model would not apply.²⁹

²⁸ Train (2009), pp. 35-36.

²⁹ In his book, Dr. Train discusses what the researcher should do if he or she believes the IIA assumption is not satisfied. His first suggestion is to use one of the more advanced demand models that are the focus of the book. Dr. Singer did not follow this suggestion. Dr. Train's second suggestion is to include enough additional variables in the logit model to reduce the unobserved portion of utility to white noise. But, as I have already

C. Is a per-unit pass-through rate necessarily greater than an ad valorem passthrough rate in this case? If so, why? Does this affect the reliability of Dr. Singer's pass-through formula?

1. Summary Answer

30. The economics literature and my correction to Dr. Singer's formula, which is consistent with that literature, demonstrate that the per unit pass-through rate is necessarily greater than an ad valorem pass through rate in the context of Dr. Singer's logit model. Accordingly, Dr. Singer's pass-through formula—which incorrectly treats the ad valorem service fee as a per unit fee—is simply wrong and substantially overstates the pass-through of the (ad valorem) service fee. Because it is wrong and in a way that results in a substantial overstatement of damages, Dr. Singer's pass-through formula cannot be considered reliable.

2. Detailed Answer

31. The answer to the first part of this question is unambiguous: under Dr. Singer's logit model, the per unit pass-through rate is necessarily greater than the ad valorem pass-through rate.

32. The difference in pass-through rate between an ad valorem tax and a per unit tax has been studied in the economics literature over a long period of time, starting in the 1950s. At that time, modern models of imperfect competition—in which suppliers sell differentiated products and face downward sloping demand curves that allow for price to exceed marginal cost in equilibrium, such as the logit demand model used by Dr. Singer—had not yet been developed. Thus, Suits and Musgrave (1953) focused on the polar case of a monopolist (the other polar case is perfect competition, discussed further below). They showed that, for a monopolist, the pass-through rate

discussed, Dr. Singer did not follow that suggestion either. Dr. Train's third suggestion is to proceed with the flawed logit model as an "approximation," but he notes that the "viability" of this suggestion depends on the goals and, in particular, he notes that when interest centers around getting substitution patterns correct, a flawed logit model tends not to provide a good approximation. Train (2009), p. 36.

of a per unit tax is greater than the pass-through rate of an ad valorem tax that raises the same amount of revenue.³⁰

33. With the development of modern models of imperfect competition, economists have compared per unit tax pass-through and ad valorem tax pass-through in those models. The most comprehensive treatment to date is Adachi and Fabinger (2022).³¹ Adachi and Fabinger (2022) find that, just as with a monopolist, in a general model of imperfect competition among firms with the same demand functions and constant marginal costs, the pass-through rate of a per unit tax is greater than the pass-through rate of an ad valorem tax.³² In fact, they demonstrate that the pass-through rate for an ad valorem tax is obtained by multiplying the pass-through rate for a per unit tax by an adjustment factor equal to one minus the inverse of a firm's own elasticity of demand (in absolute value). Thus, for example, if the firm's own elasticity of demand (in absolute value) is 1.11, the pass-through rate for an ad valorem tax is only $(1 - 1/1.11) = 10\%$ of the pass-through rate for a per unit tax. That is, if the pass-through rate for a per unit tax were 91.1% (such as the figure Dr. Singer derived), the pass-through rate for an ad valorem tax would be only 9.1%.

34. I note that, in my correction of Dr. Singer's pass-through formula, the adjustment factor I derived is equal to the Adachi and Fabinger (2022) factor multiplied by $1/(1-v)^2$ where v is the ad

³⁰ D. Suits and R. Musgrave, "Ad Valorem and Unit Taxes Compared," *Quarterly Journal of Economics*, 1953, pp. 598-604: "For the monopoly case the following propositions apply...3. If the same yield is obtained from a unit and an ad valorem tax, the final price will be higher (the output smaller) under the unit tax."

³¹ T. Adachi and M. Fabinger, "Pass-Through, Welfare, and Incidence Under Imperfect Competition," *Journal of Public Economics*, 2022 ("Adachi and Fabinger (2022)"), pp. 1-27.

³² See Adachi and Fabinger (2022), p. 11, which shows that the pass through rate for an ad valorem tax is equal to the pass through rate for a per unit tax multiplied by a factor equal to $\frac{\epsilon_{own}-1}{\epsilon_{own}}$, where ϵ_{own} is a supplier's own elasticity of demand (in absolute value). Note that $\frac{\epsilon_{own}-1}{\epsilon_{own}} = 1 - \frac{1}{\epsilon_{own}}$.

valorem tax percentage.³³ Thus, if the service fee percentage is 30%, my adjustment factor in the example above is $(1-1/1.11)/0.7^2 = 20\%$, which is larger than Adachi and Fabinger (2022)'s adjustment factor.³⁴ For example, given a per unit tax pass-through of 91.1% (the figure derived by Dr. Singer), applying my adjustment results in a 18.6% ad valorem tax pass-through rate.

35. As I discuss in my Report, many apps are likely to have a low ratio of marginal cost to price.³⁵ A low ratio of marginal cost to price also implies a relatively low own elasticity of demand. For example, if the ratio of marginal cost to price is 10%, the implied own elasticity of demand (in absolute value) is 1.1 under the types of models of imperfect competition that Dr. Singer himself has used in this case.³⁶ As discussed above, with an own elasticity of demand of 1.1, Adachi and Fabinger (2022) find that the ad valorem pass through rate is only 10% of the per unit pass through rate, and with a cost to price ratio of 10%, my correction to Dr. Singer's per unit pass-through rate results in an ad valorem pass through rate of 18.6%. Thus, for many apps, Dr. Singer's pass-through formula will substantially overstate the pass-through of the ad valorem service fee. As an aside, it is important to recognize that the relatively small pass-through of an ad valorem service fee in this theoretical setting, together with frictions such as a developer's

³³ My adjustment factor is $\frac{c}{p} \frac{1}{(1-v)^2}$. Leonard Report, Appendix D. In an oligopoly model such as that studied by Adachi and Fabinger (2022), the ratio of a firm's marginal cost to its price, i.e., $\frac{c}{p}$ is equal to $1 - \frac{1}{\epsilon_{own}}$. Thus, my adjustment factor can also be written as $(1 - \frac{1}{\epsilon_{own}}) \frac{1}{(1-v)^2}$.

³⁴ There is no inconsistency between my correction to Dr. Singer's formula and Adachi and Fabinger (2022). The difference in the adjustment factors arises because of a difference in the way marginal cost is defined in Dr. Singer's approach (including the service fee in marginal cost) and in Adachi and Fabinger (2022) (not including the service fee in marginal cost).

³⁵ Leonard Report ¶ 128.

³⁶ Singer Report ¶ 295 ("Equation (V.1) simplifies to what is known as the Lerner index, the standard inverse elasticity formula... This expression is widely recognized in economic theory and suggests that firms with pricing power increase prices until the markup of price over marginal cost is equal to the inverse of the firm's own-price elasticity.")

desire to use price points ending in 99, can explain my finding of little pass-through of the service fee reductions that Google has implemented in the real world. These same conditions would inhibit pass-through in the but-for world as well.

36. Adachi and Fabinger (2022) go on to apply the formulas from their general model of imperfect competition to explicitly address the case of logit demand assumed by Dr. Singer.³⁷ Consistent with the general case, the calculations presented in Adachi and Fabinger (2022) show that, under logit, the pass-through rate for an ad valorem tax is substantially less than the pass-through rate for a per unit tax.

37. There are two differences between the imperfect competition models studied by Adachi and Fabinger (2022) and the logit model Dr. Singer uses in this case. However, neither of these differences affect the basic thrust of Adachi and Fabinger (2022)’s result that the pass-through rate for an ad valorem tax is substantially less than that for a per unit tax. First, in their setting, Adachi and Fabinger (2022) assume firms have the same share in equilibrium, whereas Dr. Singer’s logit model allows firms to have different shares. However, later in their paper, Adachi and Fabinger (2022) address the case of heterogeneous firms and find the same basic result.³⁸ Moreover, my correction to Dr. Singer’s pass-through formula also allows firms to have different shares. Second, Adachi and Fabinger (2022) assume that a tax would apply to every firm and study the resulting pass-through, while Dr. Singer assumes that the service fee increase would affect only a single

³⁷ See Adachi and Fabinger (2022), pp. 13-16. The authors call it the “multinomial logit model,” but this is just another term for the logit model that Dr. Singer uses. Also, while they address both price-setting and quantity-setting behavior, I focus on price-setting as that is more relevant for apps and that was the assumption of the Miller, et al. (2013) paper on which Dr. Singer based his pass-through formula. See Singer Report ¶ 358; N. Miller, et al., “Using Cost Pass-Through to Calibrate Demand,” *Economics Letters*, 2013, pp. 451-454. In any event, the results are similar under quantity-setting.

³⁸ See, e.g., Adachi and Fabinger (2022), Figure 7.

firm.³⁹ As my correction to Dr. Singer's formula shows, however, the Adachi and Fabinger (2022) result continues to hold when the ad valorem tax (or ad valorem service fee) is applied to only one firm.

38. At the "hot tub," Dr. Singer noted that Suits and Musgrave (1953) also discuss the case of perfect competition and that, in that case, the per unit tax pass-through rate is equal to the ad valorem tax pass-through rate. That is true. However, the app industry is not perfectly competitive and thus the result for perfect competition does not apply, contrary to what Dr. Singer seemed to imply. Under perfect competition, each supplier sells a homogeneous product and faces a perfectly elastic demand curve, i.e., has no pricing power, and in equilibrium price is equal to marginal cost. Wheat farming is the prototypical example of perfect competition. However, in the software industry and for apps specifically, fixed costs (e.g., development costs) tend to be large relative to marginal cost. Consequently, price must be well above marginal cost in equilibrium so that development and other fixed costs are covered, not equal to marginal cost as with perfect competition. Second, apps are not homogeneous products, as under perfect competition, but rather differentiated products (not perfect substitutes for each other). Third, as a result of the differentiation, developers are price-setters and recognize that how they set their price affects the demand for their product, which again is not the case with firms under perfect competition. Importantly, the very logit demand function that Dr. Singer has chosen to use assumes that each developer faces a downward sloping demand curve, which allows the setting of price above marginal cost, unlike in perfect competition.⁴⁰ In short, the app industry is an example of imperfect

³⁹ Despite making this assumption himself, I understood Dr. Singer to be criticizing me for making the same assumption when I corrected his formula.

⁴⁰ In fact, the own price elasticities of demand implied by Dr. Singer's regression analysis are low, indicating that the demand curves faced by developers are far from horizontal as would be necessary for perfect competition.

competition among differentiated products, not perfect competition.⁴¹ Therefore, the Adachi and Fabinger (2022) result is the relevant one for the app industry.

39. The intuition for the ad valorem tax pass-through rate being less than the per unit tax pass-through rate centers around the fact that the tax revenue per unit generated by an ad valorem tax increases as the price increases, while the tax revenue per unit generated by a per unit tax remains the same. This means that, for a developer, the additional marginal cost associated with the ad valorem tax is less than the additional marginal cost associated with the per unit tax even when the two taxes generate the same tax revenue. For example, under a per unit tax (T), if the developer considers a price decrease (ΔP) that would increase sales by 1 unit, the marginal cost for that additional unit would be the developer's non-tax marginal cost plus the per unit tax, or $(MC + T)$. However, under an ad valorem tax (v) that generated the same tax revenue (i.e., $vP = T$), the marginal cost for the additional unit would be approximately equal to the non-tax marginal cost plus the ad valorem tax rate times the price (which is the same dollar amount as the per unit tax by assumption) minus the ad valorem tax rate times the absolute value of the price decrease times the number of units sold $(MC + vP - v\Delta PQ)$. The last term, $-v\Delta PQ$, which has no counterpart under a per unit tax, makes the overall marginal cost lower under the ad valorem tax than under the per unit tax $(MC + vP - v\Delta PQ < MC + T)$. This term arises because when the developer lowers its price, it gets the benefit of paying a lower tax on all of its existing sales, which represents a decrement to marginal cost. With a lower overall marginal cost, the developer sets a lower price

⁴¹ I use the term "imperfect competition" to represent cases between the polar extremes of monopoly and perfect competition. When a product is differentiated, but still a (less than perfect) substitute for other products, the product's seller is neither a monopolist (because the product's price is constrained by competition from the substitutes) nor a perfect competitor (because the substitutes are not perfect). In particular, the seller faces a demand curve that is less than perfectly elastic, giving it some latitude in price-setting.

under the ad valorem tax than under the per unit tax. That is, the developer passes through less of the tax amount in the case of an ad valorem tax than a per unit tax. The key to this result is that a developer faces a downward sloping demand curve (as is the case with logit demand) and sets a price above marginal cost in equilibrium.

40. To summarize, the literature shows that, under imperfect competition, including a differentiated products industry with logit demand, the ad valorem pass-through rate is less than the per unit pass-through rate. Dr. Singer's protestations to the contrary are entirely unfounded and incorrect. Dr. Singer claims that he just used the formula in Miller, et al. (2013). However, that paper is studying a per unit tax, not an ad valorem tax. Thus, Miller, et al. (2013) does not support Dr. Singer's application of its per unit tax pass-through formula to the case of an ad valorem tax.⁴² Moreover, my correction to Dr. Singer's pass-through formula is consistent with the literature.

41. Because Dr. Singer's pass-through formula is derived assuming a per unit service fee and the literature shows that pass-through for an ad valorem service fee would be less, Dr. Singer's pass-through formula substantially overstates the extent of pass-through of the service fee in this case. Given that it is inconsistent with the literature, incorrect, and off by a large enough amount to make a substantial difference for damages, Dr. Singer's formula cannot be considered reliable.

⁴² See Miller, et al. (2013): "Now suppose that a per-unit tax is levied on each product in the model - the tax perturbs marginal costs and allows for the derivation of cost pass-through."

D. For the Play Points analysis, Dr. Singer used the example of AT&T in the 1980s as a benchmark for modeling the but-for world, positing that Google's market share would likely decline to 60% with competition, just as AT&T's did decades ago. Is the AT&T case an example of a two-sided market like the Google Play Store? Does that matter for its appropriateness for use as a benchmark here?

1. Summary Answer

42. The economics of AT&T's long-distance service differed substantially from the Play store. Importantly, the Play store is a true two-sided matching platform with associated cross-side feedback loops. Specifically, the Play store facilitates matches between consumers and developers who have joined the platform. Consumers value Play more when there are more developers on the platform and developers value Play more when there are more consumers on the platform, creating the feedback loops. AT&T long distance service in the 1980s and early 1990s did not share this important economic characteristic with the Play store. For example, an AT&T long distance subscriber could place a long-distance call to recipients who were not AT&T subscribers. Thus, the value of AT&T long distance service to a subscriber did not depend on the number of potential recipients who were also AT&T subscribers.

2. Detailed Answer

43. A basic requirement for the validity of a benchmark is that it be similar in economic characteristics to the but-for world being modeled. Otherwise, market outcomes in the benchmark do not provide a reliable guide to market outcomes in that but-for world. The economics of long distance service in the 1980s and early 1990s differed substantially from the but-for world for Android app stores in this case, and thus there is no reason to think that any Android app store

entrants in the but-for world in this case would have achieved the 40% share that MCI, Sprint, and other long distance competitors to AT&T achieved in the 1980s and early 1990s.⁴³

44. As I discussed in my Report, at a fundamental level, the nature of the products/services being offered is entirely different and as a result so are the technologies used. Accordingly, without an in-depth analysis, there is absolutely no basis to think that the entry costs, requirements, and market opportunity for one or more new firms to compete with the incumbent would be the same in the Android app store marketplace as was the case in the 1980s and early 1990s long distance service marketplace.⁴⁴ This should be enough to disqualify the latter as a benchmark for the former.

45. However, there is a further crucial economic attribute of the Play store that AT&T long distance service in the 1980s and early 1990s did not share. The Play store exists to facilitate matches between two distinct groups of users of the Play store platform—consumers and developers. For a match to occur (e.g., a consumer identifying and downloading a useful app), both users must be on the Play store. The matching aspect of the Play store creates a cross-side feedback loop. The more consumers are on the Play store, the more attractive the Play store is to developers. Conversely, the more developers are on the Play store, the more attractive the Play store is to consumers. AT&T long distance was fundamentally different in this regard. Subscribers to the AT&T service used AT&T to place long distance calls. These calls could be placed to any recipient, whether an AT&T, MCI, or Sprint subscriber. The recipients of calls placed by AT&T subscribers need not have been, and often were not, subscribers to the AT&T service themselves.

⁴³ Leonard Report ¶ 91.

⁴⁴ Leonard Report ¶ 92.

Thus, the attractiveness of AT&T long distance service to callers did not depend on how many recipients were also AT&T subscribers. This means that AT&T long distance service did not have the same type of cross-side feedback loop that is central to the economics of the Play store.

46. The economics literature has recognized the importance of cross-side feedback loops for market outcomes.⁴⁵ Therefore, given that AT&T long distance service did not have such a cross-side feedback loop makes it an entirely inappropriate as a matter of economics to use market outcomes for AT&T long distance in the 1980s and early 1990s as a benchmark for market outcomes for the Play store, for which the cross-side feedback loop is fundamental, in the but-for world.

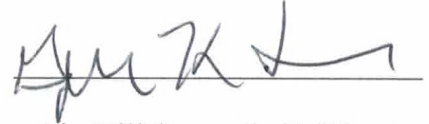
47. There is no firm consensus among economists regarding the exact definition of a “two-sided platform,” although most economists would include as a requirement the existence of cross-side feedback loops.⁴⁶ Accordingly, it is possible that some economists may use a definition that encompasses long distance service. However, this is just semantics with no economic content; the

⁴⁵ B. Caillaud B. Bruno Jullien, “Chicken & Egg: Competition Among Intermediation Service Providers,” *RAND Journal of Economics*, 2003, pp. 309-310 (“In these activities, users have larger expected gains, the larger the number of users on the other side of the market, a property referred to as indirect network externalities. This is the case, for instance, for individuals visiting a matchmaking (e.g., dating) service, for sellers of goods and services participating in a marketplace, as well as for buyers, because a large number of sellers gives them access to more diversity.”); D. Evans, et al., *Invisible Engines: How Software Platforms Drive Innovation and Transform Industries*, MIT Press, 2006, p. 4 (“Most successful software platforms have exploited positive feedbacks (or network effects) between applications and users: more applications attract more users, and more users attract more applications.”).

⁴⁶ See A. Hagiu and J. Wright, “Multi-Sided Platforms,” *International Journal of Industrial Organization*, 2015, p. 163: “Existing definitions of MSPs suffer from excessive specificity, over-inclusiveness, or being too vague to be of use. As a result there is disagreement among those in the literature about what constitutes an appropriate definition. The most common approach to date has focused on the presence of important cross-group or indirect network effects between the two or more customer groups participating on the platform.”

relevant substantive economic point is that the Play store has strong cross-side feedback loops and AT&T long distance service did not.⁴⁷

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct.

A handwritten signature in black ink, appearing to read "Gregory K. Leonard", is written over a horizontal line.

Executed on this 14th day of August in Hillsborough, California.

⁴⁷ Plaintiffs' experts in this case agree that Play has cross-side feedback loops and that such feedback loops are a defining characteristic of two-sided platforms. See Singer Report ¶ 187; Expert Report of Steven Schwartz, PhD, October 3, 2022, ¶ 138; Expert Report of Dr. Marc Rysman, October 3, 2022, ¶ 135; Opening Expert Report of B. Douglas Bernheim, PhD, October 3, 2022, ¶ 171.

EXHIBIT A



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Dr. Gregory K. Leonard is a vice president in the Antitrust & Competition Economics Practice of CRA. He specializes in applied microeconomics and econometrics. He has provided testimony before US federal and state courts, government agencies, and arbitration panels on issues involving antitrust, damages estimation, statistics and econometrics, surveys, valuation, and labor market discrimination.

Dr. Leonard has written extensively in the areas of antitrust, industrial organization, econometrics, intellectual property, class certification, and labor economics. His publications have appeared in journals such as the *RAND Journal of Economics*, the *Journal of Industrial Economics*, the *Journal of Econometrics*, the *International Journal of Industrial Organization*, and the *Antitrust Law Journal*, among others. Dr. Leonard's writings were cited by the Court of Appeals for the Federal Circuit in its *Uniloc* decision and his trial testimony was cited by the Supreme Court in its *Oracle v. Google* decision. He is currently a Senior Editor (and formerly the Editorial Board Vice Chair for Economics) of the *Antitrust Law Journal* and has served as a referee for numerous economic journals.

Dr. Leonard has given invited presentations on antitrust and intellectual property issues at the (US) Federal Trade Commission, the US Department of Justice, the former Anti-Monopoly Bureau of China's Ministry of Commerce, the Supreme People's Court of China, and Japan's Fair Trade Commission. He served as a consultant on the issue of immunities and exemptions to the (US) Antitrust Modernization Commission.

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Presentations

"Merger Analysis with Differentiated Products," paper presented to the Economic Analysis Group of the US Department of Justice, April 1991 (with J. Hausman and D. Zona).

"Assessing Use Value Losses Due to Natural Resource Injury," paper presented at "Contingent Valuation: A Critical Assessment," Cambridge Economics Symposium, April 3, 1992 (with J. Hausman and D. McFadden).

"Contingent Valuation and the Value of Marketed Commodities," paper submitted to the Contingent Valuation Panel of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, August 12, 1992 (with J. Hausman).

“Economic Analysis of Differentiated Products Mergers Using Real World Data,” paper presented to the George Mason University Law Review Antitrust Symposium, October 11, 1996 (with J. Hausman).

“Documents Versus Econometrics in Staples,” paper presented to a program of the Economics Committee of the ABA Antitrust Section, September 5, 1997 (with J. Hausman).

Discussant, “New Developments in Antitrust” session, AEA meetings, January 7, 2000.

“In Defense of Merger Simulation,” Department of Justice and Federal Trade Commission Merger Workshop, Unilateral Effects Session, February 18, 2004.

Discussant, “Proving Damages in Difficult Cases: Mock Trial & Discussion,” NERA Antitrust & Trade Regulation Seminar, July 10, 2004.

“Network Effects, First Mover Advantage, and Merger Simulation in Damages Estimation,” LSI Workshop on Calculating and Proving Patent Damages, July 16, 2004.

“Early Exchange of Documents,” LSI Workshop on Pre- and Early Stage Patent Litigation, July 23, 2004.

“Lessons Learned From Problems With Expert Testimony: Antitrust Suits,” LSI Workshop on Effective Financial Expert Testimony, November 4, 2004.

“Price Erosion and Convoyed Sales,” LSI Workshop on Calculating & Proving Patent Damages, January 19, 2005.

“Economic Analysis of Rule 23(b)(3),” LSI Litigating Class Action Suits Conference, June 6, 2005.

“Early Exchange of Documents,” LSI Workshop on Pre- & Early-Stage Patent Litigation, July 22, 2005.

“Issues to Consider in a Lost Profits Damages Analysis,” Patent Litigation 2005, Practicing Law Institute, September 30, 2005.

“Antitrust Issues in Standard Setting and Patent Pools,” Advanced Software Law and Practice Conference, November 3, 2005.

“New Technologies for Calculating Lost Profits,” LSI Workshop on Calculating & Proving Patent Damages, February 27, 2006.

“Estimating Antitrust Damages,” Fair Trade Commission of Japan, April 21, 2006.

“Economic Analysis of Rule 23(b)(3),” LSI Litigating Class Action Suits Conference, May 11, 2006.

“Permanent Injunction or Damages: What is the Right Remedy for Non-Producing Entities?,” San Francisco Intellectual Property Law Association/Los Angeles Intellectual Property Law Association Spring Seminar, May 20, 2006.

“Antitrust Enforcement in the United States” and “Economic Analysis of Mergers,” Sino-American Symposium on the Legislation and Practice of Anti-Trust Law, Beijing Bar Association, Beijing, People’s Republic of China, July 17, 2006.

“Economic Analysis in Antitrust,” Chinese Academy of Social Sciences, Beijing, People’s Republic of China, July 20, 2006.

“Issues to Consider in a Lost Profits Damages Analysis,” Patent Litigation 2006, Practicing Law Institute, September 26, 2006.

“Comparison of the Almost Ideal Demand System and Random Coefficient Models for Use With Retail Scanner Data,” Pacific Rim Conference, Western Economic Association, Beijing, People’s Republic of China, January 12, 2007 (with F. Deng).

Discussant, “Applied Economics” Session, Pacific Rim Conference, Western Economic Association, Beijing, People’s Republic of China, January 12, 2007.

“Balancing IPR Protection and Economic Growth in China,” International Conference on Globalization and the Protection of Intellectual Property Rights, Chinese University of Political Science and Law, Beijing, People’s Republic of China, January 20, 2007.

“The Use and Abuse of Daubert Motions on Damages Experts: Lessons from Recent Cases,” LSI Workshop on Calculating & Proving Patent Damages, February 27, 2007.

“Will Your Licenses Ever be the Same? Biotechnology IP Strategies,” BayBio 2007 Conference, April 26, 2007.

“Tension Between Antitrust Law and IP Rights,” Seminar on WTO Rules and China’s Antimonopoly Legislation, Beijing, People’s Republic of China, September 1, 2007.

“Issues to Consider in a Lost Profits Damages Analysis,” Patent Litigation 2007, Practicing Law Institute, September 25, 2007.

Discussant, “Dominance and Abuse of Monopoly Power” Session, China’s Competition Policy and Anti-Monopoly Law, J. Mirrlees Institute of Economic Policy Research, Beijing University, and the Research Center for Regulation and Competition, Chinese Academy of Social Sciences, Beijing, People’s Republic of China, October 14, 2007.

“Opening Remarks,” Seminar on China’s Anti-monopoly Law and Regulation on Abuse of Intellectual Property Rights, Beijing, People’s Republic of China, April 26, 2008.

“Issues to Consider in a Reasonable Royalty Damages Analysis,” Patent Litigation 2008, Practising Law Institute, October 7, 2008.

“Econometric Evaluation of Competition in Local Retail Markets,” Federal Trade Commission and National Association of Attorneys General Retail Mergers Workshop, December 2, 2008,

“Merger Review Best Practices: Competitive Effects Analysis,” International Seminar on Anti-Monopoly Law: Procedure and Substantive Assessment in Merger Control, Beijing, People’s Republic of China, December 15-17, 2008.

“The Use of Natural Experiments in Antitrust,” Renmin University, Beijing, People’s Republic of China, December 18, 2008.

“China’s Antimonopoly Law: An Economist’s Perspective,” Bloomberg Anti-Monopoly Law of China Seminar, January 29, 2009.

Panelist, “Standards for Assessing Patent Damages and Their Implementation by Courts,” FTC Hearings on the Evolving IP Marketplace, February 11, 2009.

“Economic Analysis of Agreements Between Competitors” and “Case Study: FTC Investigates Staples’ Proposed Acquisition of Office Depot,” Presentation to Delegation of Antitrust Officials from the People’s Republic of China, Washington, DC, March 23, 2009.

“Reasonable Royalties in the Presence of Standards and Patent Pools,” LSI Workshop, April 20, 2009.

Presentations on Unilateral Effects, Buyer Power, and the Intellectual Property-Antitrust Interface to Delegation from the Anti-Monopoly Bureau of MOFCOM of the People’s Republic of China, Washington, DC, May 10-11, 2009.

Panelist, “The Use of Economic and Statistical Models in Civil and Criminal Litigation,” Federal Bar Association, San Francisco, May 13, 2009.

“Trends in IP Rights Litigation and Economic Damages in China,” Pursuing IP in the Pacific Rim, May 14, 2009.

Presentation on the Economics of Antitrust, National Judicial College of the People’s Republic of China, Xi’an, People’s Republic of China, May 25-26, 2009.

“Case Study: The Use of Economic Analysis in Merger Review,” Presentation to the Anti-Monopoly Bureau of MOFCOM, Beijing, People’s Republic of China, May 27, 2009.

“Economics and Antitrust Law,” China University of Political Science and Law, Beijing, People’s Republic of China, September 21, 2009.

“Case Study: Economic Analysis of Coordinated Interaction,” Presentation to the Anti-Monopoly Bureau of MOFCOM, Beijing, People’s Republic of China, September 22, 2009.

“Relevant Market Definition,” 4th Duxes Antitrust Law Seminar, Beijing, People’s Republic of China, September 26, 2009.

“Expert Economic Testimony in Antitrust Litigation,” Supreme People’s Court, Beijing, People’s Republic of China, February 2, 2010.

“New Case Law for Patent Damages,” Law Seminars International Telebriefing, April 28, 2010.

“China/India: Sailing in Uncharted Waters: Regulating Competition in the Emerging Economies – New Laws, New Enforcement Regimes and No Precedents,” The Chicago Forum on International Antitrust Issues, Northwestern University School of Law Searle Center, May 20, 2010.

“Antitrust and Intellectual Property,” Supreme People’s Court, Beijing, People’s Republic of China, May 26, 2010.

“Cartel Enforcement Trends in the United States,” 2nd Ethical Beacon Anti-Monopoly Summit, Beijing, People’s Republic of China, May 27, 2010.

Panelist, “The Future of Books and Digital Publishing: the Google Book Settlement and Beyond,” 2010 American Bar Association Annual Meeting, August 7, 2010.

“Coordinated Effects” and “Non-Horizontal Mergers,” Presentations to Delegation from India Competition Commission, US Chamber of Commerce, Washington, DC, October 26, 2010.

“UPP and Merger Simulation,” Annual Conference of the Association of Competition Economics, Norwich, UK, November 11, 2010.

“Uniloc v. Microsoft: A Key Ruling For Patent Damages,” Law Seminars International Telebriefing, January 21, 2011.

“Correlation, Regression, and Common Proof of Impact,” New York City Bar Association, January 19, 2011.

“Private Litigation Under China’s New Antimonopoly Law,” Bar Association of San Francisco, February 17, 2011.

“Competition Law and State Regulation: Setting the Stage and Focus on State-Owned Enterprises,” Competition Law and the State: International and Comparative Perspectives, Hong Kong, People’s Republic of China, March 18, 2011.

Panelist, “Booking it in Cyberspace: The Google Book Settlement and the Aftermath,” American Intellectual Property Law Association, San Francisco, May 13, 2011.

“Econometric Estimation of Cartel Overcharges,” ZEW Conference on Economic Methods and Tools in Competition Law Enforcement, Mannheim, Germany, June 25, 2011.

Panelist, "Antitrust and IP in China," Antitrust and IP in Silicon Valley and Beyond, American Bar Association and Stanford University, Palo Alto, October 6, 2011.

Panelist, University of San Diego School of Law Patent Law Conference: The Future of Patent Law Remedies, January 18, 2013.

"Economics Framework," US-China Workshop on Competition Law and Policy for Internet Activities, China's State Administration for Industry and Commerce (SAIC) and the U.S. Trade and Development Agency (USTDA), Shenzhen, People's Republic of China, June 4-5, 2013.

Panelist, "China Inside and Out," American Bar Association, Beijing, People's Republic of China, September 16-17, 2013.

Panelist, "Remedies in Patent Cases," Fifth Annual Conference on The Role of the Courts in Patent Law & Policy, Berkeley and Georgetown Law Schools, November 1, 2013.

"Royalty Base," Leadership Conference, Qualcomm Incorporated, March 21, 2014.

"Reflections on Natural Experiments," DG Comp, April 8, 2014.

Panelist, "Antitrust in Asia: China," American Bar Association Section of Antitrust Law, Beijing, People's Republic of China, May 21-23, 2014.

Panelist, "Patent Damages Roundtable," 2015 Intellectual Property Institute, University of Southern California Gould School of Law, Los Angeles, March 23, 2015.

Panelist, "IP and Antitrust – The Current State of Economic Analysis," Global Competition Review Live 2nd Annual IP & Antitrust USA, Washington, DC, April 14, 2015.

Panelist, "FRAND Royalty Rates After Ericsson v. D-Link," American Bar Association, May 15, 2015.

Participant, Patent Damages Workshop, University of California-Berkeley, March 3, 2016.

Panelist, "FRANDtopia – In a Perfect World," LAIPLA Spring Conference, May 5, 2018.

Panelist, "Chicago Forum on International Antitrust Issues," Northwestern Pritzker School of Law, June 15, 2018.

Panelist, "Competition in Digital Advertising: Is There Online and Offline Convergence?," Challenges to Antitrust in a Changing Economy, Harvard Law School, November 8, 2019.

Testimonies given in the last four years

Plexxikon Inc. v. Novartis Pharmaceuticals Corporation, United States District Court for the Northern District of California, Case No. 4:17-CV-04405-HSG (EDL), 2019 (Deposition), Trial Testimony (2021).

Press Ganey Associates, Inc. v. Qualtrics, LLC, American Arbitration Association, Case No. 01-18-0004-4674, 2019 (Deposition).

In the Matter of: Determination of Rates and Terms for Digital Performance of Sound Recordings and Making of Ephemeral Copies to Facilitate those Performances (Web V), before the United States Copyright Royalty Board Library of Congress, Docket No. 19-CRB-0005-WR (2021-2025), 2020 (Deposition, Trial Testimony).

Abiomed Inc. v. Maquet Cardiovascular LLC, United States District Court for the District of Massachusetts, Case No. 1:16-cv-10914-FDS, 2020 (Deposition).

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In the Matter of Certain Digital Video-Capable Devices and Components Thereof, Investigation No. 337-TA-1224, United States International Trade Commission, 2021 (Deposition).

Teradata US, Inc., Teradata Corporation and Teradata Operations, Inc. v. SAP SE, SAP America, Inc. and SAP Labs LLC, United States District Court for the Northern District of California, Case No. 3:18-cv-03670-WHO, 2021 (Depositions).

American Society of Composers, Authors and Publishers v. Radio Music License Committee, Arbitration, 2021 (Hearing Testimony).

PureWick Corporation v. Sage Products, LLC, United States District Court for the District of Delaware, Case No. 1:19-cv-01508-MN, 2021 (Deposition), 2022 (Trial Testimony).

In Re Caustic Soda Antitrust Litigation, United States District Court for the Western District of New York, Case No. 1:19-cv-003895-EAW-MJR, 2022 (Deposition).

Bedford, Freeman & Worth Publishing Group, LLC d/b/a Macmillan Learning, Macmillan Holdings, LLC, Cengage Learning, LLC, Elsevier Inc., Elsevier B.V., McGraw Hill LLC, and Pearson Education Inc. v. Shopify, Inc., United States District Court for the Eastern District of Virginia, Case 1:21-cv-01340, 2022 (Deposition).

Athos Overseas, Ltd. v. YouTube, LLC and Google LLC, United States District Court for the Southern District of Florida, Miami Division, Case No. 1:21-cv-21698-DPG, 2022 (Deposition).

In Re Google Play Store Antitrust Litigation, United States District Court for the Northern District of California, San Francisco Division, Case No. 3:21-md-02981-JD, Case No. 3:21-cv-05227, 2023 (Deposition, Hearing).

Broadcom Corporation et al. v. Netflix, Inc., United States District Court for the Northern District of California, San Francisco Division, Case No. 3:20-CV-04677-JD, 2023 (Deposition)

Professional activities

Member, American Economic Association

Member, Econometric Society

Member, American Bar Association

Contributor, www.antitrust.org

Contributor, ABA Section of Antitrust Law, *Econometrics*, 2005

Associate Editor, *Antitrust*, 2007-2010

Senior Editor, *Antitrust Law Journal*, 2012-2019, 2023-; Vice Chair for Economics, 2019-2023; Associate Editor, 2010-2012

Co-Editor, ABA Section of Antitrust Law Economics Committee Newsletter, 2009-2012

Member, Economics Task Force, ABA Section of Antitrust Law, 2011-2012

Member, ABA Delegation to International Seminar on Anti-Monopoly Law: Procedure and Substantive Assessment in Merger Control, Beijing, People's Republic of China, December 15-17, 2008.

Member, Working Group for drafting the "Joint Comments of the American Bar Association Section of Antitrust Law and Section of International Law on the MOFCOM Draft Guidelines for Definition of Relevant Markets," 2009.

Member, Working Group for drafting the "Joint Comments of the American Bar Association Section of Antitrust Law and Section of International Law on the SAIC Draft Regulations on the Prohibition of Acts of Monopoly Agreements and of Abuse of Dominant Market Position," 2009.

Member, Working Group for drafting the "Joint Comments of the American Bar Association Section of Antitrust Law and Section of International Law on the SAIC Draft Regulations on the Prohibition of Acts of Monopoly Agreements and of Abuse of Dominant Market Position," 2010.

Referee: *Econometrica*, *Review of Economics and Statistics*, *International Journal of Industrial Organization*, *Review of Industrial Organization*, *Journal of Sports Economics*, *Journal of Environmental Economics and Management*, *Research in Law and Economics*, *Labour Economics*, *Eastern Economic Journal*, *Journal of Forensic Economics*, *Antitrust*, *Antitrust Law Journal*, *Journal of Competition Law and Economics*, *Advances in Econometrics*.

Professional history

12/2019–Present	<i>Vice President</i> , Charles River Associates
2012–2019	<i>Partner</i> , Edgeworth Economics
2008–2012	<i>Senior Vice President</i> , NERA Economic Consulting
2004–2008	<i>Vice President</i> , NERA Economic Consulting
2000–2004	<i>Senior Vice President</i> , Lexecon, Inc.
1991–2000	<i>Director</i> , Cambridge Economics, Inc.
1990–1991	<i>Senior Analyst</i> , NERA Economic Consulting
1989–1990	<i>Assistant Professor</i> , Columbia University
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